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PREDICTING THE NUMBER OF GRADUATES WITH COMPLETE SECONDARY EDUCATION IN UKRAINE BY MEANS OF BROWN'S MODEL

Аннотация. *В статье представлены результаты оценки качества временного ряда численности выпускников с полным общим средним образованием в Украине, обоснован выбор модели Брауна, а также получены прогнозные значения.*

Since 2003, a sharp decrease in student recruitment is observed in Ukraine in higher education, which is explained by the demographic situation that prevailed in the country at the end of the twentieth century. When forming the contingent of students of higher educational institutions is dominated by graduates with complete secondary education, and therefore prediction of their numbers is an urgent task for today.

When predicting the socio–economic processes mathematical methods which allow evaluating their dynamics play an important role. For this purpose, the times series are constructed which are a series of changes in the time value of statistical indicators, arranged in chronological order. For their study the methods of extrapolation of trends are widely used, which are based on the assumption that past patterns of the object are transferred to the future.

Methods for the extrapolation of trends are used in the short–term (less than one year) forecasting when the number of changes in the environment is minimal. The group forecast extrapolation methods can include the method of least squares, exponential smoothing, probabilistic modeling and adaptive anti–aliasing. The extrapolation methods of forecasting have been studied by such scientists as V.V. Vitlinsky A.I. Yastremsky, P.I. Verchenko and others.

Since the main objective of socio–economic forecasting is to build predictive models, the best way to describe the dynamics of development, in the prediction of such processes adaptive models are used. Adaptive models allow us to take greater account of the current information, and to a lesser extent – of the past. The main feature of these models is to change the coefficients of the model constructed with the new information, that is, the adaptation of the models to the new data [1–3]. One such method is an adaptive method of Brown. By adaptation refers to the ability of the system to use the new information to approximate their behavior and structure to optimally under the new conditions. Self–learning – it is the ability of the system to adapt to the new conditions, adjust their behavior, taking into account the errors. Adaptive model is well suited for the study of short time series, an example of which is a time series of the number of graduates.

The general scheme of construction of adaptive models can be represented as follows. According to some elements of the first time series, values of model parameters are evaluated. Then, this model is based on the forecast of one step forward, and its deviation from the actual value of the time series is regarded as a prediction error, which is accounted for in accordance with the correction scheme model. Further, the

predictive estimate is calculated on the model taking into account the adjusted parameter for the next time, etc. Thus, the model is constantly learning, absorbing new information, and by the end of the training period reflects the trend of the development process, which is being investigated.

It is known that, depending on the development trend of the test process, there are three models of Brown:

- zero–order – if the process is random and has no trends

$Y(t+\tau)=A_0;$ (1)

- first order – if the investigated processes inherent linear trend

$Y(t+\tau)=A_0+A_1\tau;$ (2)

- second order – if it is characterized by a parabolic trend

$Y(t+\tau)=A_0+A_1\tau+A_2\tau^2.$ (3)

In order to predict the number of graduates by means of the Brown model corresponding to the time series for the last 26 years has been studied (from 1990 to 2015.) [4]. The method of turning points was used to determine the trends of dynamics development of the number of graduates with complete secondary education in Ukraine. As a result, the following values were obtained:

- estimated value of the number of turning points – P=5;
- tabulated values of the turning points – P_L=12 и P_U=20 [5].

Since the condition $P < P_L$ is executed, we can conclude that the time series of the number of graduates with a full general secondary education in Ukraine is characterized by a trend. In this regard, to predict the number of graduates Brown models were constructed of the first and second order (2) and (3), approximation results for which are shown in Fig.

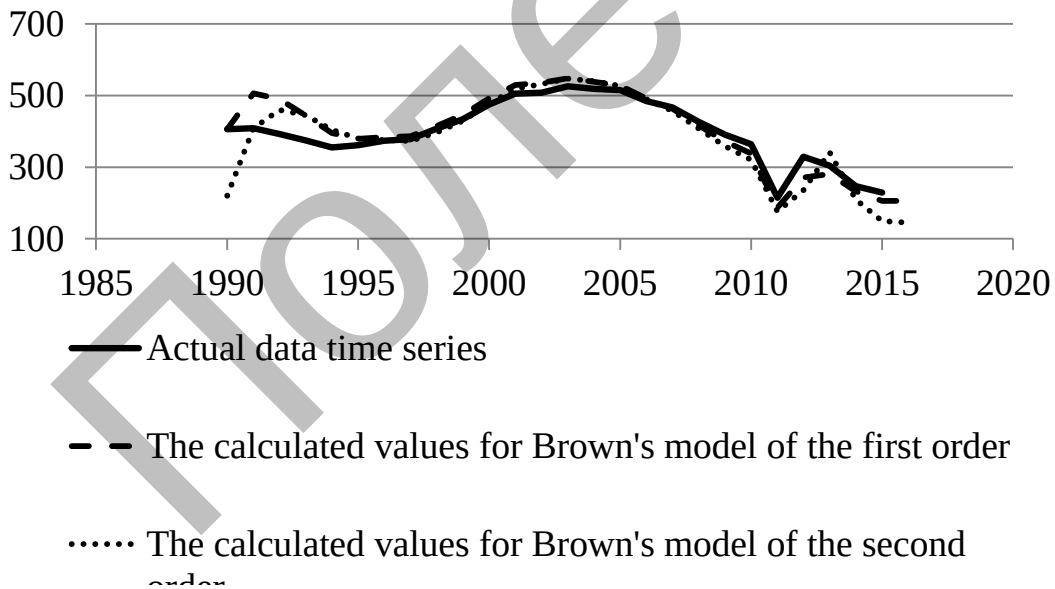

Fig. The results of the approximation and forecasting the number of graduates with a full general secondary education in Ukraine by means of the Brown model

These models are characterized by the following quality criteria – the average value of the prediction error:

- Brown's model of the first order – 0,072;
- Brown's model of the second order – 0,101.

On the basis of this, decision was made to use the Brown model of the first order in order to predict, which showed that in 2016 the predicted value of the number of

graduates with a full general secondary education in Ukraine will be 206 thousand people, which, in turn, indicates the further trend of decrease this indicator.

Thus, studies have shown the permissibility of using Brown's model for the short–term forecasting of short time series of number of graduates with a full general secondary education in Ukraine. The selection of the model order has been justified by the method of turning points, as well as quality criteria – the average value of the prediction error.

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